Internet Use and Cybersecurity Concerns of Individuals with Visual Impairments

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ABSTRACT

Twenty individuals with visual impairments were surveyed in order to (a) understand their Internet use and (b) examine relations between metrics related to Internet use and cybersecurity-related knowledge, skills, confidence, and attitudes. Participants used the Internet for various purposes, including information search, communication, chatting, shopping, socialization, and education. The latter was more prevalent than in past research. Participants who were more knowledgeable and skilled regarding cybersecurity tended to be more concerned about it and to use the Internet less than those who were less knowledgeable about cybersecurity. Thus, cybersecurity concerns may lead individuals with visual impairments to decrease their Internet use, which could widen the digital divide.

Keywords

Accessibility, Internet use, Individuals with visual impairments, Disabilities, Cybersecurity

Introduction

According to the 2012 National Health Interview Survey, about nine percent (21.5 million) of the adult population in the U.S. had some kind of visual impairment. The American Printing House for the Blind (2012) reported that there were over 500,000 children who were blind in the United States. In addition to the congenitally blind population, the number of people with adventitious blindness, people who have lost their vision later in life, is also significant. For instance, the Blinded Veterans Association (http://www.bva.org) reports that around 7,000 veterans in the United States are vulnerable to lose their vision and become blind or visually impaired each year in addition to about 165,000 who are already blind or visually impaired. According to the 2012 Disability Status Report, about 24.6 % of people who are blind or visually impaired are employed full-time (Erickson, Lee, & von Schrader, 2014). Given the fact that most corporations conduct their daily business affairs online through computers and the Internet, it is vital to educate people who are visually impaired in the of use computers at home and/or work.

The Internet and assistive technology can help people with disabilities maximize their potential and achieve personal, professional, and educational objectives (Brady, Morris, Zhong, White, & Bigham, 2013; Hersh, & Johnson, 2010). Basically, these technologies allow them to have access to information, work independently, execute errands such as shopping, participate in education and training, and communicate and socialize with others (Ari & Inan, 2010; Asuncion et al., 2012; Barile, Fichten, & Asuncion, 2012; Koustriava & Papadopoulos, 2014; Shuster, 2002). There are various challenges that Internet users who are visually impaired experience when surfing the Web, including cybersecurity concerns and accessibility issues (Domingo, 2012; Olalere & Lazar, 2011; Vigo & Brajnik, 2011). Even though a great number of preventative measures have been taken to make technologies, and in particular the Internet, more accessible, users with visual impairments still may have safety concerns when navigating the Internet. It is apparent that fear of cyber-attacks and exposure of sensitive information as well as limited accessibility of the Internet and its features hinder the benefit that users with visual impairments may enjoy.

Cyber-attacks are the primary concern, threatening the U.S. infrastructure, economy, and civilian's safety. The Internet Security Threat Report published by Symantec Inc. (2014) shows an overall 91% increase in targeted attacks and 62% increase in the number of breaches in 2013. It is alarmingly a major concern that over 552 million identities were exposed and about 38% of mobile users have experienced mobile cybercrime in the same year. The estimation of the annual cost of cybercrime to the global economy is more than $400 billion (McAfee, Inc., 2014). The increasing number of cyber-crime incidents occurring in cyber-space raises the alarm and need for better protection and guards for individuals and, in particular, those with visual impairments.

Internet use by individuals who are visually impaired

Individuals with a disability could utilize various Internet services for banking, shopping, training, and social networking. Previous studies indicated that Internet use for communication (e.g., email) was the most commonly observed activity among individuals with visual impairments (Kaye, 2000). Surfing on the Internet for fun, listening to music, and social media involvement were among the other most frequently identified Internet activities (Kaye, 2000; Kelly & Wolffe, 2012). Although it was not common, the use of the Internet for banking, shopping, and educational purposes was also found to be substantial (Ari & Inan, 2010; Kaye, 2000). However, findings from previous studies suggest that people with visual impairments tend to use computers and the Internet at rates below the average for the general population, indicating that a major digital divide still exists for users who are visually impaired (Kelly & Smith, 2008). Dobransky and Hargittai (2006) found that people with disabilities are less likely to use computers and are less likely to be online. According to a U.S. Department of Commerce report (2013), Internet use in the U.S. among households with people with a disability is only 48% compared to 76% for households with people with no disability. Similarly, a recent Oxford Internet Institute 2013 report from the United Kingdom presented similar findings that indicate that only 51% of people with a disability use the Internet, which is considerably less than the 84% of non-disabled respondents who use the Internet (Dutton & Blank, 2013).

In order to allow easy access to the Internet, there are a number of free Web browsers that are specifically designed for users who are blind (Bigham, Prince, & Ladner, 2008; Borodin, Mahmud, Ramakrishnan, & Stent, 2007). The use of assistive technology integrated with these Web browsers enables Internet users who are visually impaired to navigate and access the Web more easily. In addition to these accessible Web browsers, a number of free and commercial screen readers are also available to users with a visual disability (Department of Human Services, 2014). Although screen readers enable accessibility to the content, they may not always be usable. Lazar et al. (2007) listed the top five causes of frustration faced by users when using screen readers: (a) confusing layout; (b) technical conflicts between the screen readers and applications; (c) poorly designed forms; (d) no alternate text for images; and (e) inaccessibility to PDF files. Most screen readers have other limitations such as text-based presentation, linear access to information, inaccessibility of visual objects, loss of contexts, and repetition of reading (Chandrashekar, 2010). In addition, realization of the content structure of a Web page is extremely hard for a person who is visually impaired. For example, identifying specific information inside a table is one of the most difficult tasks for someone visually impaired (Gunderson & Mendelson, 1997; Murphy, Kuber, McAllister, Strain, & Yu, 2008).

Internet users who are visually impaired are more vulnerable to cyber-attacks due to absence or limitation of visual cues, inaccessibility of visual cues, and lack of software support to inform the users about the potential cybersecurity threats. In addition to challenges due to design of Web pages, there are other security challenges that users who are blind confront when surfing the Web, including the use of CAPTCHA, login sessions and timeouts, security updates, malware, and phishing (Holman, Lazar, & Feng, 2008). There have been some efforts to make CAPTCHA more accessible for users who are blind, using integration of sonification and sound with CAPTCHA (Lazar et al., 2012; Shirali-Shahreza & Shirali-Shahreza, 2011). Similar attempts have been made to improve users' browser interaction through use of sonification techniques (Morley, Petrie, O'Neill, & McNally, 1999; Petrucci et al., 2000). However, these efforts are far below the expectations to meet the actual needs of individuals with visual impairments.

Definitions

Cybersecurity Threats: Any potentially harmful processes and actions performed to (1) access and use private information (e.g., identity theft), (2) attempt to deceive and scam users (e.g., spam emails), (3) install software intended to perform an unauthorized process (e.g., viruses & malware), or (4) directly attack computer systems and networks (e.g., hacking).

Individuals with Visual Impairments: Individuals who are functionally blind or have low vision who may use screen reader programs to carry out computing tasks.

Screen Readers: Specially designed software programs which convert text displayed on the computing device screen to audible text.

Cybersecurity Skills: Individuals' ability to perform required tasks to secure computing devices and to manage cyber security threats.

Cybersecurity Confidence: Individuals' perceptions about their own skills, knowledge, and capabilities to accomplish specific tasks to deal with cybersecurity issues.

Cybersecurity Knowledge: Individuals' awareness and understanding of cybersecurity issues and risks associated with cyber threats.

Attitudes toward Cybersecurity Threats: Individuals' intrinsic feelings of distress and discomfort due to cybersecurity concerns.

Purpose of the study

This manuscript reports the results of a survey conducted with twenty individuals who are visually impaired. The purpose of this study was to investigate the use of the Internet by individuals who are visually impaired and explore their cybersecurity challenges and concerns while surfing the Internet. Findings of this study will help to identify the major concerns and challenges of this group of Internet users and determine their assistive technology needs.

More specifically, the following research questions were addressed:

- What types of assistive technologies and software tools are used by individuals with visual impairments?
- What types of Internet and social media activities are carried out by individuals with visual impairments?
- What types of cybersecurity concerns do individuals with visual impairments have while browsing the Internet?
- Is there any common pattern between the types of Internet activities, cybersecurity concerns, and individuals' cybersecurity knowledge, skills, confidence and attitudes?

Methodology

Participants

The participants of this study were twenty individuals with visual impairments over the age of 18. The participants were recruited through a special purpose school serving students who are blind or visually impaired (n = 7) and an adult rehabilitation center (n = 13) in Texas. The questionnaires were directly administrated to each of the participant by a trained research assistant. The majority of participants were individuals who were blind (90%) and about half of the participants were female (45%). The range of participants' ages was between 20 and 59 years old. Most participants (60%) were employed. In terms of ethnicity, the largest portion of the participants was white (65%). Table 1 presents the demographics and background characteristics of the participants in more detail.

Table 1. Participants' demographic characteristics

	N	*%*
Gender		
Female	9	45
Male	11	55
Age		
19 years or younger	1	5
20 - 29 years	8	40
30 - 39 years	6	30
40 - 49 years	4	20
50 - 59 years	1	5
Ethnicity		
Black / African American	2	10
Caucasian / White	13	65

Hispanic / Latino	6	30
Education level		
Did not complete High School	2	10
High School/GED	8	40
4-Year College/Bachelor's Degree(BA, BS)	8	40
Master's Degree	2	10
Types of visual impairments		
Person who is blind	18	90
Person with low vision	2	10
Currently employed		
Yes	12	60
No	8	40

Data collection instruments

A survey investigating the cybersecurity concerns of individuals with visual impairments was developed and used for data collection. The survey consisted of four major sections: (1) demographics and background (2) technology/Internet use, (3) cybersecurity threats and concerns, and (4) cybersecurity knowledge, attitudes, beliefs, and confidence. The first section of the survey consisted of several demographic and background questions (e.g., gender, age, education, and employment status). The second part included a set of questions tailored to gather information about participants' Internet use and experiences. The third section included items to gather cybersecurity concerns of participants while using the Internet. The fourth section was made up of four sub-scales with 24 items regarding participants' cybersecurity knowledge and skills, attitude, and confidence. The majority of the items were created by a team of researchers including experts from special education, instructional technology, psychology, and computer science fields. The survey development was based on previous research and other data collection instruments (c.f., Ari & Inan, 2010; Asuncion et al., 2012; Lazar et al., 2007; National Cyber Security Alliance, 2010, 2011, 2012; WebAIM, 2014). Specifically, a section about social media was adapted from Asuncion et al. (2012) with the permission of the authors. In order to build an accessible instrument, survey design guidelines for persons who are visually impaired proposed by Kaczmirek & Wolff (2007) were followed.

Procedures

The data collection procedures began once potential participants were identified through professional networking and other recruitment methods. Participants were contacted via telephone or email, and a meeting time and location was scheduled. Participants either read a consent form prior to meeting or had the form read to them before the interview, at which point the participant signed the consent form. Interview questions were read aloud and multiple choice answers were marked by the research assistant interviewer. The open-ended questions were read aloud, and the participants' answers were written verbatim. Following each interview, the interviewer input the answers into an online survey form that was submitted to the researchers at Texas Tech University. Interviewee questions about the survey were written verbatim, as were any requests for clarification and the verbal clarification that followed. This material and any other discussion material was typed into a field notes document that was shared with the researchers.

Results

Computing devices and assistive equipment

The results indicated that the participants were using a variety of assistive technologies, computing devices, and software applications. Laptops and smartphones were the most commonly reported devices by 90% of the participants. In regard to operating systems on computing devices, MS windows on laptop/desktop and iOS on smartphone/tablet devices were the dominant options. JAWs on desktop/laptops and Voiceover on

smartphone/tablets were the primary screen reader applications used. Additionally, diverse assistive technology devices were used with braille embossers, screen readers, optical character recognition, and voice recognition being the most commonly used tools. Table 2 presents the frequency of assistive and computing devices used by the participants.

Table 2. Use of computing devices, software, and assistive technologies

	N	*%*
Ownership of computing devices		
Desktop computer	13	65
Laptop computer	19	95
Tablet	9	45
Smartphone	19	95
Operating system on laptop/desktop computer		
Windows	20	100
Apple/Mac	2	10
Unix/Linux	3	15
Operating system on tablet or smartphone device		
iOS (e.g., iPhone)	19	95
Android (e.g., Samsung Galaxy)	5	25
Windows (e.g., Nokia Lumia)	1	5
Screen reader program on desktops or laptops		
JAWS	17	85
NVDA	2	10
Other (Multiple programs)	1	5
Screen reader program on tablets or smart phones		
VoiceOver	15	75
TalkBack for Android	4	20
Other	1	5
Use of assistive technology Eequipment		
Braille embosser	14	70
Screen reader	20	100
Braille notetaker	11	55
Refreshable braille display	9	45
Optical character recognition (OCR) software	14	70
Video magnifier	2	10
Magnification software	2	10
Voice recognition	14	70

Internet activities and social media

The survey data revealed that the most common activity was reading and writing emails as reported by 80% of the participants. Other common activities frequently or extensively performed by the participants included browsing the Internet for entertainment purposes (70%), downloading and uploading files (70%), and performing educational tasks (65%). In regard to the participants' social media involvement within the past month, the most frequent activities included listening to a podcast (83.3%), using instant messaging services (77.8%), updating status on personal web spaces (77.8%), and adding someone to personal web spaces (77.8%). Table 3 and 4, and Figure 1 and 2 present the Internet and social media activities of participants.

Table 3. The frequencies of participants' Internet activities

	NE (%)	R (%)	O (%)	F (%)	E (%)
Browsing Internet for fun (e.g., news, entertainment)	5	--	25.0	45.0	25.0
Reading and writing emails	--	--	20.0	45.0	35.0
Chatting & instant messaging	20.0	25.0	20.0	25.0	10.0
Listening to music and/or watching videos	10.0	15.0	30.0	40.0	5.0

Social networking (Facebook, MySpace, Twitter, etc.)	15.0	5.0	35.0	30.0	15.0
Playing games	45.0	30.0	15.0	10.0	
Formal or informal education (online courses, research)	--	10.0	25.0	35.0	30.0
Shopping	15.0	15.0	25.0	25.0	20.0
Banking	20.0	10.0	35.0	20.0	15.0
Making online payments	15.0	20.0	30.0	15.0	20.0
Downloading and uploading files	5.0	20.0	5.0	45.0	25.0

Note. NE = Never, R = Rarely, O = Occasionally, F = Frequently, E = Extensively.

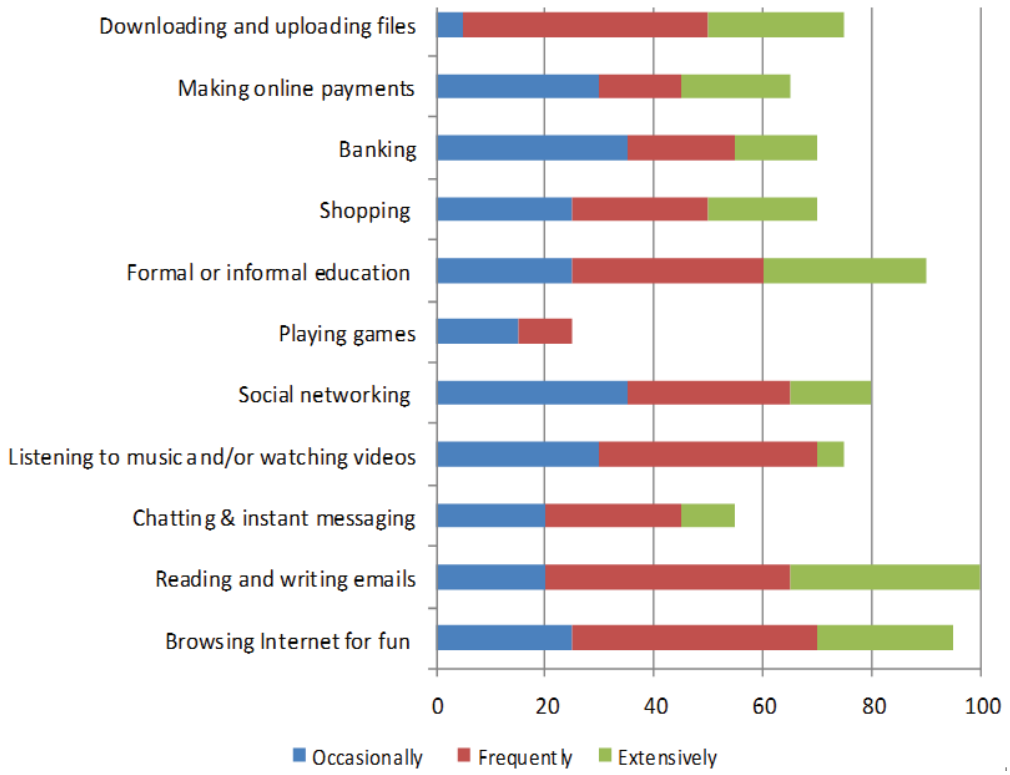

Figure 1. Participants' Internet activities

Table 4. Participant involvement in social media activities

	Yes	%
Read a Twitter post	6	33.3
Replied to / shared someone's Twitter post	5	27.8
Read a blog	11	61.1
Contributed to a blog	4	22.2
Listened to a podcast	15	83.3
Participated in multiplayer online gaming	3	16.7
Used MSN / Windows Live Messenger, Skype, Google Talk or another instant messaging service	14	77.8
Searched for someone on Facebook, MySpace, etc.	12	66.7
Uploaded a photo / video to Facebook, MySpace, etc.	4	22.2
Shared content (e.g., a link to a website) using Digg, Delicious, or another social book marking service	5	27.8
Updated your status on Facebook, MySpace, etc.	14	77.8
Added someone you know using Facebook, MySpace, etc.	14	77.8
Added someone you do not know /have never met before using Facebook, MySpace, etc.	5	27.8
Participated in web-based discussion forums	10	55.6

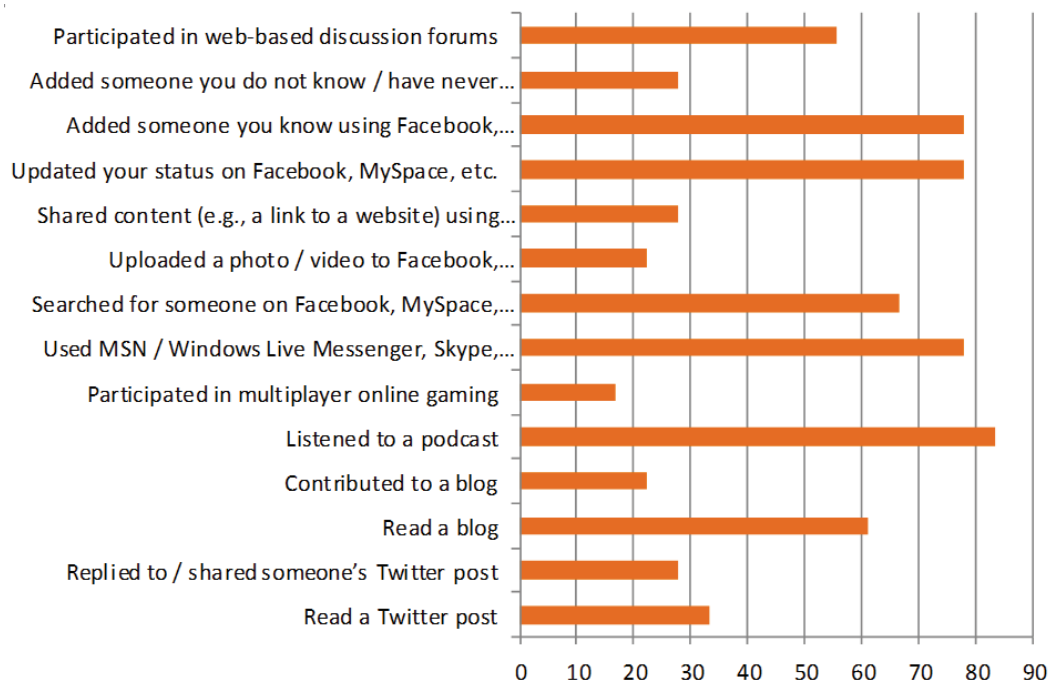

Figure 2. Participants' social media use

Problems and concerns while using the Internet

The survey results indicated that the participants often come across various problems/issues while browsing the Internet. The participants frequently experienced difficulty with security- related issues (e.g., misleading links) and other problems mainly due to the improper design of the Web pages (e.g., missing alt text descriptions). Table 5 and Figure 3 show the frequencies of problems participants experience while using the Internet.

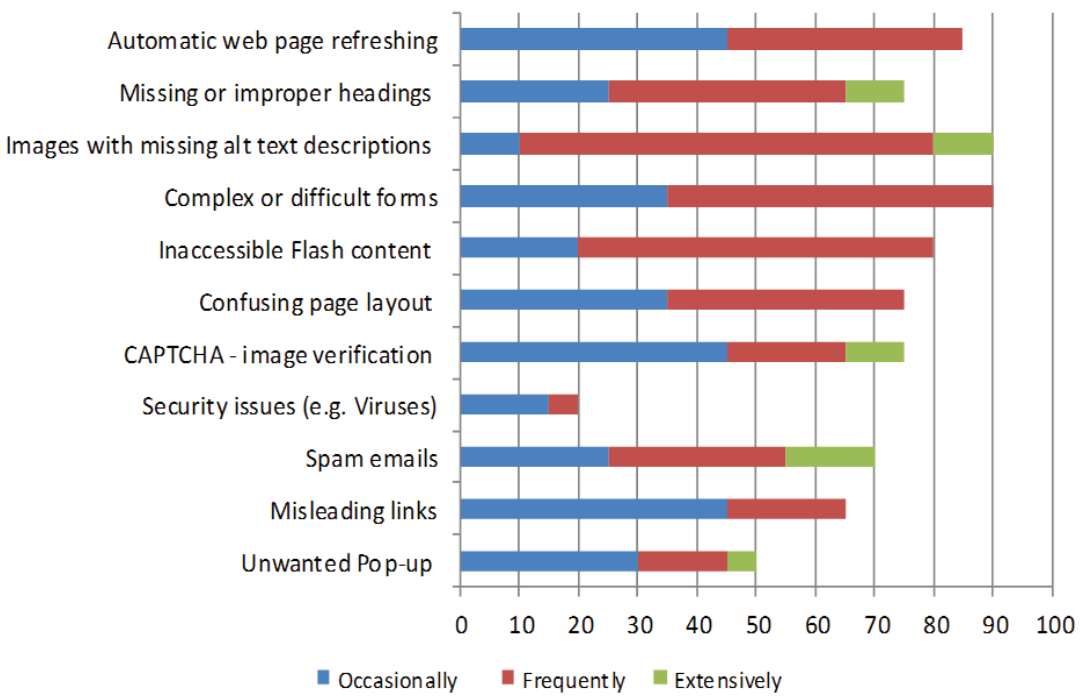

Figure 3. Problems while using the Internet

Table 5. Frequencies of problems while using the Internet

	NE (%)	R (%)	O (%)	F (%)	E (%)
Unwanted Pop-up	10.0	40.0	30.0	15.0	5.0
Misleading links	5.0	30.0	45.0	20.0	--
Spam emails	15.0	15.0	25.0	30.0	15.0
Security issues (e.g., viruses, unauthorized software)	35.0	45.0	15.0	5.0	--
CAPTCHA - image verification	15.0	10.0	45.0	20.0	10.0
Confusing page layout	--	25.0	35.0	40.0	--
Inaccessible Flash content	5.0	15.0	20.0	60.0	--
Complex or difficult forms	--	10.0	35.0	55.0	--
Images with missing alt text descriptions	--	10.0	10.0	70.0	10.0
Missing or improper headings	10.0	15.0	25.0	40.0	10.0
Automatic web page refreshing	--	15.0	45.0	40.0	--

Note. NE = Never, R = Rarely, O = Occasionally, F = Frequently, E = Extensively.

When asked about their cybersecurity threats and concerns, the majority of the participants (80%) reported their feeling as concerned or very concerned. In regard to specific issues, someone stealing private information (70%) or gaining access to financial information (65%) and personal information being made public (65%) received the highest concern rating while the possibility of a computing device getting infected with a virus or malware (35%) received the lowest rating. Table 6 and Figure 4 report the participants' level of concern about the various issues while using the Internet.

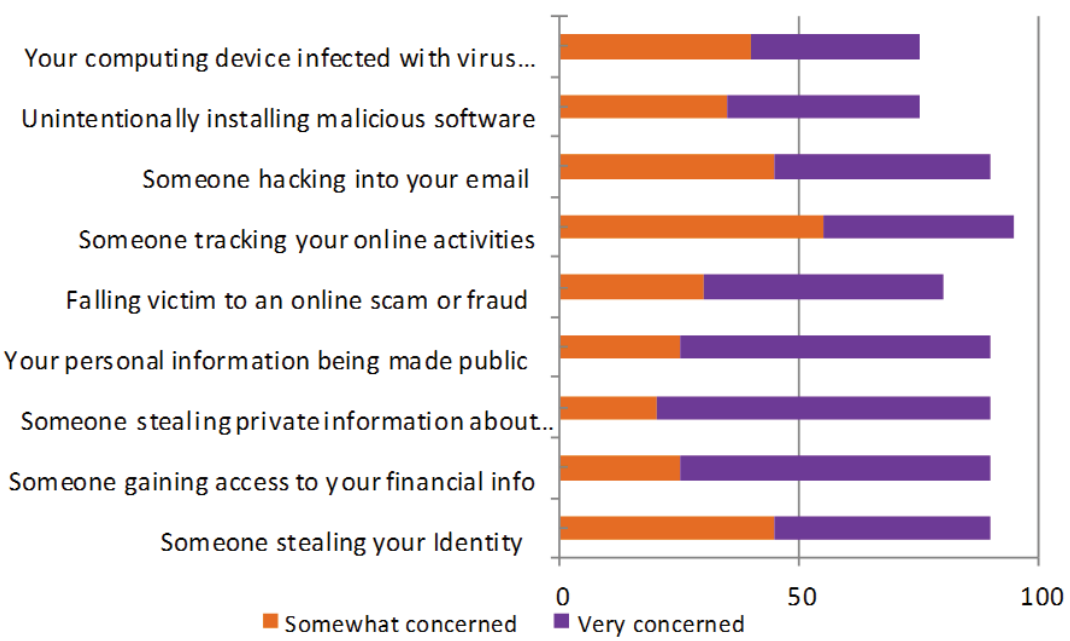

Figure 4. Participants' cybersecurity concerns

Table 6. Participants' level of concern about the issues while using the Internet

	VC (%)	SC (%)	N (%)	SU (%)	VU (%)
Someone stealing your Identity	45.0	45.0	10.0	--	--
Someone gaining access to your financial information	65.0	25.0	5.0	--	5.0
Someone stealing private information about you/your family	70.0	20.0	10.0		
Your personal information being made public	65.0	25.0	10.0		
Falling victim to an online scam or fraud	50.0	30.0	10.0	10.0	
Someone tracking your online activities	40.0	55.0		5.0	
Someone hacking into your email	45.0	45.0	10.0		

Unintentionally installing malicious software	40.0	35.0	15.0	5.0	5.0
Your computing device infected with virus or malware	35.0	40.0	15.0	5.0	5.0

Note. VC = Very concerned; SC = Somewhat concerned; N = Neutral; SU = Somewhat unconcerned; VU = Very unconcerned.

Cybersecurity knowledge, skills, confidence, and attitudes

An examination of participants' cybersecurity knowledge, skills, confidence, and attitudes indicated that the participants had moderate mean scores on these constructs ranging from 2.24 to 2.51. The Pearson correlation coefficients (Hinkle, Wiersma, & Jurs, 2003) were computed to investigate whether any correlation existed between these factors and the level of cybersecurity concern, frequency of internet activities, social media involvement, and frequency of internet problems/issues. Participants' knowledge and skills had statistically significant negative correlations with level of cybersecurity concern ($r(20) = -.603$, $p < .01$ and $(20) = -.500$, $p < .05$) and frequency of Internet activities ($r(20) = -.602$, $p < .01$ and $r(20) = -.515$, $p < .05$). On the other hand, frequency of Internet issues/problems was found to have a positive and statistically significant correlation with the frequency of internet activities ($r(18) = .523$, $p < .05$) and social media involvement ($r(18) = .640$, $p < .01$). The correlation coefficients, means, and standard deviations are shown in Table 7.

Table 7. Correlations, means, and standard deviations

Variables	1	2	3	4	5	6	7	8
Cybersecurity Skills	1							
Cybersecurity Knowledge	.808**	1						
Cybersecurity Confidence	.777**	.773**	1					
Attitudes Toward Cybersecurity Threats^^	-.328	-.244	-.291	1				
Level Cybersecurity Concern^	-.603**	-.500*	-.437	.544*	1			
Frequency Of Internet Activities	-.602**	-.515*	-.543*	.224	.239	1		
Social Media Involvement	-.318	-.042	-.007	.359	.182	.695**	1	
Frequency of Internet Issues and Problems	.118	.182	-.018	-.167	-.245	.523*	.640**	1
Mean	2.24	2.39	2.51	2.51	1.69	3.26	6.78	3.07
SD	.63	.72	.79	.74	.52	.67	3.15	.56

Note. ^Lower score indicates positive attitude; ^^lower score indicates high level of concern. *Significant at the 0.05 level; **Significant at the 0.01 level.

Discussions

The purpose of this study was to explore Internet use by individuals with visual impairment. The study also explored participants' concerns toward cybersecurity threats and relations between participants' cybersecurity concerns and the frequency of Internet activities. In terms of Internet use, the results showed that various activities were being used by the individuals. Among those, email communication and browsing the Internet for fun/information were the most frequently reported activities. Previously conducted studies documented a similar pattern in regard to usage that individuals with visual impairment commonly use email for communication and interaction (Kaye, 2000; Kelly & Wolffe, 2012). However, this study also revealed an increased use of the Internet for education purposes. This shift is probably due to the movement to provide more accessible educational opportunities for learners via online platforms (Pearson & Koppi, 2002; Seale, 2013; Seale & Cooper, 2010). Social networking and listening to music and other activities such as banking and shopping were also commonly reported Internet activities. Among those frequent social media uses were the use of social networking websites, podcasting, and instant messaging. This trend suggests that the extent of Internet usage was broad; individuals with visual impairments are exploring various new ways to use the Internet for communication, shopping, and socialization (Asuncion et al., 2012).

In regard to the Internet accessibility problems and security concerns while using the Internet, the results of this study revealed that critical issues were mainly related to the design of the websites (e.g., missing alternate text, complex forms, auto refreshing pages, etc.). Among those, the navigation structure and website organization were the commonly reported difficulties due to the lack of accessible design and the overwhelming amount of information

presented on the web pages (Lazar et al., 2007). Such difficulties force individuals with visual impairments to spend an excessive amount of time to individually complete their intended tasks or to rely on other people for acquiring information or completing tasks. Webpages not meeting accessibility guidelines along with the difficulties related to security (e.g., unwanted pop-ups and misleading links) could easily result in user frustration (Lazar et al., 2007). Examination of user concerns showed that the majority of the cybersecurity threats received a serious concern rating. Among those concerns, the possibility of someone tracking their Internet activities was the highest-rated concern. These concerns related to security and privacy of personal information may keep many from engaging in online social activities and becoming online consumers. Reports from various organizations such Business Software Alliance and eMarketer indicated that about 60% of the U.S. population was affected by concerns about Internet security (Brant, 2009; Miller & Washington, 2006). Similarly, according to the UK Office of Fair Trading report, about 80% of web users were concerned about the security of their payment details when shopping online (Lomas, 2007). These concerns are probably higher for individuals with visual impairments as they do not receive sufficient cybersecurity feedback from browsers which may inhibit positive user experience (Wentz & Lazar, 2011). Therefore, it is important to guide the user in enabling security settings and to provide accessible software solutions to protect and warn the user who is visually impaired about cybersecurity threats while using the Internet.

Examination of participants' data revealed that individuals have a moderate level of knowledge, confidence, and skill in cybersecurity. Furthermore, participants' knowledge and skills were found to be related to their level of cybersecurity concerns, suggesting that when participants have a high level of cybersecurity knowledge and skills, their concerns were also high toward cybersecurity threats (Mohamed & Ahmad, 2012). Additionally, there were relationships between participants' knowledge, skills, confidence, and frequency of Internet activities. However, the direction of the relationship was negative, suggesting that individuals with higher knowledge, skills, and confidence less frequently use the Internet for various activities. This result may be due to users having changed their behavior because of security concerns, as previous research found that users with security concerns are less likely to disclose personal information, buy goods, and bank online (European Commission, 2013). Media reports of mega breaches and major hacking instances may create public avoidance and a high degree of hesitancy toward Internet use for online shopping and online social networking (Riek, Böhme, & Moore, 2014). Although most people do not feel well-informed about the risks and protection from cyber threats (European Commission, 2013), they should be trained about proper security practices so that their behavior could be changed to enhance online security and make them feel more comfortable while using the Internet (McCrohan, Engel, & Harvey, 2010).

Future research should include the exploration and development of additional cybersecurity warnings for individuals who are blind or visually impaired to increase their degree of confidence in using the Internet. Collaborative research that includes software and commonly-used browser developers would enhance cybersecurity for individuals who are visually impaired on a broader basis if done from inception rather than after the fact. Including the end users with the disability in any such research is imperative. Hence, additional studies should focus on user-centric view of concerns associated with cybersecurity and should explore how these vulnerable users are reacting or responding to threats. The ongoing challenge for all accessibility issues is keeping up with the ever-changing technology and threats found on the Internet, but exploration of how to increase confidence of safety while using the Internet for individuals with visual impairment is greatly needed to provide equal access for this population.

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